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Robert Hooke's *Micrographia*

A historical guide to navigating contemporary images

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> [T]rue Philosophy… is to begin with the Hands and Eyes, and to proceed on through the Memory, to be continued by the Reason; nor is it to stop there, but to come about to the Hands and Eyes again, and so, by a continual passage round from one Faculty to another, it is to be maintained in life and strength.
>
> *Hooke (1665, p. 7)*

Curious in(ter)ventions

In 1694, at the age of sixty, nearly thirty years after he published his illustrated book, *Micrographia*, and only several years before he went blind, Robert Hooke, the natural philosopher and Curator of Experiments at the Royal Society of London, presented a new invention to his esteemed colleagues (Hooke 1694, pp. 292–296). It was a camera obscura, of sorts, which he said he had designed with seafarers and wayfarers in mind. Essentially, he considered the instrument an aid to 'curious navigators' and travellers that would allow them to visually document new worlds, irrespective of their drawing ability (Hooke, p. 295). Simply described, Hooke's apparatus was a wearable camera obscura.[1] In this chapter, I explore the idea of this seemingly improbable instrument being symptomatic of Hooke's previous engagement with microscopy. I want to suggest that the instrument provided Hooke with a way to revisit, and possibly reconcile, the paradoxical world he encountered through the compound lens of his light microscope, which he experienced in his making of *Micrographia*.[2] Printed in London in 1665, *Micrographia* is one of the first illustrated books on microscopy and certainly the most well known.[3] It was an instant bestseller, introducing the culture of the day to an extraordinary new vision.[4] I argue that *Micrographia*, when examined together with Hooke's camera obscura, can provide an insight into our contemporary engagement with images: both in the realm of science and also with images considered more broadly, i.e., in our current visual and media culture. The images I focus on in this chapter are representations (which lay claim to mirroring the real via the direct observation of specimens) rather than schematics (the graphs, symbols, diagrams that are made for the aim of simplifying quantitative abstracted data).

Firstly, let me offer a brief methodological introduction to situate my argument: I am a scholar and visual artist who works across the fields of art and science, and my understanding

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of optical technologies and drawing is through my interdisciplinary engagement with the instruments. I have based my career on exploring the history of anatomy and its visualization, at times working as a body dissector, anatomical illustrator, and lecturer in anatomy and classical drawing, both for artists and scientists, which I combine with my research interest in optics. Moreover, my current biological arts practice depends on microscopy (I tissue culture human fat cells in vitro for my art installations, e.g., *Sentinels* 2018). To elucidate my approach to laboratory-based arts and demonstrate the ways in which Hooke appears meaningful to my practice, this chapter includes a discussion of two of my artworks: the light installation, *Lucida* (2012), and biological art installation, *Sentinels* (2018). These works developed from my long-term interest in questioning the traditional history and historiography of anatomy and both were made, at least in part, in laboratories, biology and physics, respectively.[5] Yet, this point is not to imply that I anachronistically think of Hooke working in a laboratory setting or consider him to be an anatomist. Rather, I look to Hooke to gain an insight into how certain ways of seeing are formed (from a contingent coalescing of practices, materials, and ideas) and performed (sustained as enactments of visual knowledge, which can be also viewed as iterations that are open to change, i.e., offering us the possibility of seeing, and doing, otherwise).[6]

Hooke's practice of 'true philosophy' which, if understood in terms similar to those presented by historian of science, Peter Dear, in his take on the 'experimental philosophy' of the era, would emerge as 'a kind of dialectical interaction between natural philosophy and instrumentality' that could be viewed as an antecedent to modern science (Dear 2005, p. 405). By this, I mean that the philosophy would display the same unresolvable tension raised by the incompatibility of the discourses (with Dear's use of the expression 'natural philosophy' being applied here in its original conception, i.e., as a purely contemplative concern). Although Hooke embraced the Royal Society's call for the practice of experimental philosophy, his 'true philosophy,' as outlined in the epigraph above, appears more of an 'actively thinking' than a 'utilitarian doing.' Or to put it another way, Hooke appears to be undertaking a contemplative thinking with the hands rather than implementing his prior observations of the world to fabricate a projected construct of the mind with an intended 'use' value. Even the circulatory nature of his project denies an instrumental aim. Dear notes that during the Scientific Revolution, 'natural philosophers' would tend to oscillate between representations of their work, as a discourse of contemplative knowledge and a discourse of practical or useful knowledge, creating an 'uneasy alliance' between the two mutually denying extremes (Dear 2005, p. 390). Yet, Hooke's 'true philosophy' appears different again, and it is this slippage that I find of interest. Especially when reflecting on the possible ways in which artists can work within the domains of science, in particular, the life sciences, where I urge artists to deflect calls to be 'useful.' Here, I echo a sentiment that is foundational to the SymbioticA biological arts laboratory, The University of Western Australia, where 'projects are made intentionally for cultural and artistic purposes with no expectation of utilitarian ends' (Catts & Zurr 2018, p. 52). Indeed, there is great value to be found in creating 'thoughtful absurdities' that occasion us as a society to think critically and engage meaningfully (i.e., with 'life' in all its multifarious and surprising emergences) (Catts 2012, p. 31).

Examining the foundations of the ideology of modern science is of particular importance when raising questions about the contemporary life sciences, as it is a field in which the uneasy convergence of contemplation *and* utility, as outlined by Dear, easily translates into supporting calls for the 'manipulation of life.' Interrogating our era's complex and often contested notions of 'life,' and giving thoughtful consideration to the social and ethical responsibilities that arise from our apparent embrace of its technoscientific manipulation, appears

a key concern and motivation for philosophers and biological artists of the twentieth and twenty-first century (Agamben 1994; Catts & Zurr 2018; Zylinska 2009). Equally, and here my focus on *Micrographia* becomes more relevant, there is a need to critically engage with the visual materials that give rise to the knowledge of these disciplines and, in doing so, consider how these images influence society once they begin to circulate beyond the domain of science (in a sense, to take seriously the 'life' of images). I follow this idea, taking a notable point of departure from the scientific method in the theoretical underpinnings of my artworks as I bring the critical viewpoints of cultural studies and media theory into the methodology of my practice-led research. Essentially, I pursue my arts practice as a way of actively thinking through, and engaging with, ideas visually.[7] In a similar manner, when I turn to historical archives such as *Micrographia*, I view them as artefacts of a process and as an opportunity to undertake a close reading of the visual vocabulary of the material. Indeed, being literate in visual vocabularies, and their modes of production and history, is a key quality that artists can bring to the study of archives, opening them to new understandings and critique. In this way, I suggest reading this chapter not only as a historical guide to navigating contemporary images but also providing an insight into charting a particular approach to participating across the arts and sciences.[8]

Seeing

Simply described, microscopes magnify the appearance of small objects. However, in the example of Hooke, I want to suggest that it is more interesting to question the set of actions that were required in the making of *Micrographia's* magnified visions. In taking this approach what appears of particular significance is the coupling and choreography of observer and instrument in the act of observation. Hooke's experience of microscopic vision can be thought of as fundamentally altering his engagement with the world. In this way, microscopy is considered as not only modifying sight but also impacting on the body as a whole. I explore this theory through an investigation of Hooke's making of *Micrographia* and expand on the idea to connect it to Hooke's invention of a wearable camera obscura. I conceptualize Hooke's camera obscura as an extension and amplification of his phenomenological experience of microscopy and as a logical sequel to being immersed in the microscopic view. The premise of my argument is as follows: microscopy can be said to have reconfigured the intuitive understanding of space, removing touch from the process of vision, and separating form from matter through the creation of virtual images in the compounding of lenses.

To frame the discussion, I propose a particular concept of light – *the task envelope of light* – which I introduce here as a way to link the optics of Hooke's light microscope; the perspectival images contained within *Micrographia*; and Hooke's later invention of the wearable camera obscura. My intention is to provide a space in which to visualize the unfolding of Hooke's practice of 'true Philosophy' and trace its passage through his experiments with microscopy. (Keep in mind that I am a visual artist who desires ways in which to think through ideas visually.) Here, light becomes both an environment and agent (and *Micrographia's* perspectival illustrations record the mark of light's affect). This idea extends from my research into anatomy in which I consider light and anatomy not as isolated scientific entities, but rather as being embedded in their shared history of relational use, specifically, in the production of anatomical images (Sellars 2012, p. 8). I think of an anatomical image as not only conveying anatomical knowledge but also capturing traces of the initial interaction between the optics of anatomy and light (which, in turn, shapes the knowledge the image contains).[9] Conceptually, *the task envelope of light* disperses the agency of image-making (away from the

human) while locating each 'performance of anatomy' (the physical cut of dissection and imaging) within its distinct (light) environment: in effect, the images suspend the 'imaging event' spatiotemporally, thereby opening it to critique. Similar to Donna Haraway's notion of 'situated knowledges,' each imaging event occurs at a particular time and place and within a particular technological and cultural context, providing a 'partial perspective' (Haraway 1988, pp. 575–599). This passage suggests that 'the task envelope' I have in mind comprises an operational space that is defined by instrumentalized light and inclusive of a skilled observer, in this instance, Robert Hooke (1665).

The term 'task envelope' is usually associated with the instructional specifications of robotic machinery; it delineates the area covered by a piece of equipment when it is in use and determines an envelope of operational space. The specifications are generally provided for safety reasons, indicating where the body should *not* be in relation to working equipment. However, in the context of my research, my use of the term is inclusive of the body, as I conceptualize the body of the viewer forming part of an operational *optical* space. I argue that the task envelope of a light-based technology defines a perceptible limit to both the observer's action and understanding by determining what they see and by instigating how they see it. In this chapter, I provide only a minimal excursion into the idea (to facilitate this brief discussion of perspective and microscopy). Provisionally, we can think of the task envelope as setting the parameters of both a conceptual framework within which to formulate questions and, at the same time, as detailing the physical qualities of light shaping how knowledge is enacted and conveyed. Yet, this definition belies the dynamic quality of the concept that I wish to retain, and it proves useful here to align with a contemporary theory of note – *agential realism*.

To a certain extent, parallels can be drawn between the idea I put forward, *the task envelope of light*, and that of the influential theory, *agential realism*, presented by theoretical quantum physicist and feminist theorist, Karen Barad (Barad 2007). Most notably, both of the concepts call on the physical qualities of light (interacting with matter) to provide the organizing principles for their methodologies. Barad employs the optical phenomenon of diffraction, as a way to analyse patterns of difference and to offer a viable alternative to Western thought's historical reliance on the optical metaphors of reflection, i.e., metaphors identifying sameness (Barad 2007, p. 72). In part, Barad is responding to the call made by feminist theorist and philosopher, Donna Haraway, for scholars to critically engage with metaphors of diffraction – both to highlight the subtle relational nature of differences and to provide a counterpoint to self-reflexive theory (Haraway 1997). Yet, Barad extends Haraway's remit by incorporating an understanding of diffraction phenomena that is informed by quantum physics.[10] In the field of quantum mechanics, '[d]iffraction experiments are at the heart of the "wave versus particle" debates about the nature of light and matter' and make explicit the entangled state of phenomena (inclusive of the diffraction apparatus) (Barad, p. 72).[11] There is no 'outside' or 'inside' to the diffraction phenomenon. Indeed, for Barad, the world is a dynamic shifting topology of 'intra-acting' entities, not an amalgam of pre-existing discrete elements upon which one can simply reflect (from above, beyond, or outside the event) (Barad, p. 33).[12] 'Intra-actions include the larger material arrangement (i.e., set of material practices) that effects an *agential cut* between "subject" and "object" (Barad p. 139).' Barad's use of the term, *agential cut*, refers to the enactment of boundaries from within (and as part of) phenomena (compared to the usual Cartesian understanding of the world that takes the distinction between 'subject' and 'object' as a given). To be clear, a Cartesian world contains 'things' awaiting discovery, whereas, in Barad's concept of *agential realism*, 'things' don't pre-exist: they are agentially enacted.[13]

At first glance, my delving into the spaces of representationalism (i.e., the perspectival illustrations of *Micrographia* that detail Hooke's observations) would seem to indicate that my concept – *the task envelope of light* – embraces the classical geometrical optics of *reflection*, with all the problems this approach seems to entail, for example, the belief in there being a definitive separation between knower and known, premised on the existence of an observation-independent reality, which, in turn, gives no account nor accountability for how 'boundaries, properties, and meanings are differentially enacted' (Barad, p. 151). Moreover, and perhaps even more challenging to my argument, I have signalled my interest in critical theory, i.e., the very same self-reflexive theory that Haraway and Barad want us to evade. Nevertheless, I assert that my aim *is* to provide a performative account of *Micrographia*: viewing its illustrations not simply as *reflections* of a microscopic world but in terms that are comparable to Barad's notion of the *agential cut* in which 'cuts are agentially enacted not by willful individuals but by the larger material arrangement of which "we" are a "part"' (Barad, p. 178). The images in *Micrographia* perceived as momentary stabilizations – what Barad would refer to as 'exteriority-within-phenomena' – which provide a provisional resolution. Here, I am moving towards an idea expressed by media theorists, Sarah Kember and Joanna Zylinska, in their collaborative text, *Life after New Media: Mediation as a Vital Process* (2012). In the text, they offer a way of understanding our experience of life, considered as a 'being in' and a 'becoming with' our technological world, arising from 'a network of interlocked processes of mediation in which biological, political, technical, social and economic flows interconnect and intra-act' (Zylinska 2013). Media present as *cuts* made in the flow of mediation that are enacted by human and nonhuman agents alike. In their example of photography, the role of the *cut* is 'to divide photography into photographs, but then to reconnect the latter to its beyond: i.e., photographic duration whose stabilisations into artefacts are only ever temporary' (Kember & Zylinska 2012, p. 82). For Kember and Zylinska, 'an in-cision is also de-cision' entailing an ethical imperative (2012, p. 82). Similarly, Barad does not absolve us of ethical responsibilities in the reconfigurings of which we are a part. In my use of the term, *to cut*, which I derive from the literal definition of anatomy, the ethical dimension of the *cut* forms an integral component.[14] A vital process, the *cut* of anatomy is a twofold act: the physical action of cutting the body asunder and the visual cut of image-making which carves out a particular representation of the body. Yet, the *cut* of anatomy also reconnects the image to its beyond, not foreclosing on possibilities and the ethical imperative to cut well, i.e., to cut better in future iterations. This understanding echoing Kember and Zylinska's call – 'Cut. Cut again. Cut Better' (2012, p. 204). I will return to these ideas and elaborate on *the task envelope of light*, but firstly, I want to address further the following question: why is an artist who is interested in anatomy concerned with the work of Robert Hooke?

Although Hooke is not considered an anatomist and *Micrographia*, celebrated for its images of insects and plants and for its study of optics, does not contain any images of human anatomy, the moment that Hooke represents is of great consequence for the very project of anatomy. Anatomy is a science predominantly based on visual observation and uniquely reliant on images for the circulation of that knowledge. Arguably, no other optical instruments have influenced visualizations of anatomy more than perspective and microscopy, with the majority of modern scientific imaging technologies not just being derived from these two ways of seeing, but increasingly appearing as a fusion of the two, i.e., the online anatomies that provide virtual fly-throughs of even the smallest anatomical architectures. (Even beyond the subject of anatomy, this coupling appears as a visual trope of contemporary imaging.) I think of Hooke as someone signalling the emergence of this way of seeing and of *Micrographia* as being the first instance of its dissemination in society more broadly. Indeed, *Micrographia*

exposed the culture of the day to an extraordinary new concept of sight that effectively disrupted both the prevailing sensibility of scale and the intuitive understanding of space.[15] The publication assisted in shaping and accentuating seventeenth-century society's engagement with microscopic vision: habituating the eye to looking into the intangible, while tethering this new vision to the sixteenth-century illustrational paradigm of perspective. This initial sense of wonder may be lost on the twenty-first-century reader, but *Micrographia* offers the opportunity to question the continuing influence of this seventeenth-century event and ask whether repetitions are occurring which, at the same time, contain important differences.

What is significant in the example of *Micrographia* is that Hooke trained originally as an artist and was a drawer and visual communicator of great skill who was able to convey in images his own personal experience of seeing differently or otherwise.[16] Here, my use of the term 'seeing differently' relates to my interest in a particular line of media theory and cultural studies exemplified by the theorists, Gary Hall and, the above-mentioned, Joanna Zylinska. Hall and Zylinska work in the field of new media, but they are influenced by the philosophy of Jacques Derrida (Hall 2002; Zylinska 2005). In their work, I see Hall and Zylinska as extending an invitation not only to theorists but also to artists to experiment critically and creatively with theory and practice – to both question and transform the ways in which knowledge is enacted and conveyed. I pursue this idea in my close reading of *Micrographia*'s illustrations, giving thoughtful attention to the conditions and assumptions that underpin a particular way of seeing. This point indicates that when I suggest that Hooke conveys in images his personal experience of seeing differently, I mean this information to be inclusive of elements beyond what he may have intended. Seeing is a complex historical and cultural process, which exceeds any one individual's phenomenological grasp. In this way, the 'differently' as used in this chapter relates more to Derrida's philosophy of deconstruction and its application of the term, 'différance,' to indicate a non-oppositional understanding of difference.[17] Compared to, for example, the use of the term by the philosopher of science, Ian Hacking, in his text, 'Do We See Through Microscopes,' in which he questions the possibility of 'seeing differently,' or rather asks whether we can say with any certainty at all that we 'see' or 'see directly' through light microscopes (Hacking 1985). Hacking enters the (metaphysical) dispute of scientific realism/anti-realism, positioning himself as a realist (towards entities), and his accumulated acts of 'seeing differently' are undertaken for a resolution of the dialectic. There is no such resolution or synthesis offered in doing deconstruction.

In returning to *Micrographia*, the impact of the microscopic view can be discerned in several ways. Firstly, it can be seen in the treatment of visual space, as the images present a microscopic view embedded in a perspectival construct that I conceptualize as a hybridization of vision. We can think of this hybridization of vision as arising from the mixing of two *task envelopes of light* – perspective and microscopy. This meld becomes a question of physics, yet Hooke, a complex biological-cultural entity, also forms part of the task envelope. Both of the optical instruments offer Hooke a distinct mode of visualization that is defined by their individual technological configuring of light, which in many ways appear juxtaposed: the traits of one exposing the qualities of the other. For example, microscopy's optical flattening of space, which I will argue Hooke treats as a visual compression of the three-dimensional matrix of perspective, appears to conflict with Hooke's sculptural modelling of the specimens. Here, it is important to keep in mind that the hybridization that I am referring to is not a fusion of illustrational techniques, that is to say, a simple pastiche of drawing methods, occurring on the surface of the paper. It is rather a combination of optics that influenced Hooke's perception and created an inherent tension. In this way, the images can be thought of as indicative of Hooke trying to make sense of this new vision.

In microscopy, the magnification of sight enables visual access to what lies beyond our physical grasp (and our everyday notion of 'seeing'). In contrast, perspective images evoke palpable realities (and yes, here, we are problematically close to entering a debate on what is 'real' and returning to questions raised by Hacking). In these pictorial spaces, illuminated objects appear suspended in a three-dimensional matrix, with their surfaces eliciting a tactile quality through their interaction with light, captured in the illustration's conveyance of texture. By purposefully using a low-magnification (50×) compound light microscope, when more powerful magnifications were available to him (which is an important point that I will return to in a moment), Hooke positions himself on the threshold between these two ways of seeing. What Hooke encounters is an *almost* intangible, *almost* invisible realm. Indeed, my fascination with Hooke is that he appears to embody a vision on the precipice of this change; transitioning from a perspectively framed viewpoint inherited from the Renaissance to the disorientating immersion of the microscopic view. When Hooke translates his microscopic view into his drawings, a kind of conversion takes place, as he effectively solidifies the virtual forms through the process of perspective, thus making the intangible appear tangible and within reach. Yet, my reference here to the virtual subtly shifts the focus of the discussion: moving it away from the magnification of sight enabling visual access to what lies beyond our physical grasp, to instead emphasize the sense of touch, and its apparent loss, in relation to the Western understanding of form and matter.[18]

As noted by the art historian, Barbara Maria Stafford, in her research on optical technologies – in perspectival images 'representation was a physical, tangible act of illustrationally taking empirica in one's arms'; however, 'with the popularization of microscopy… touch dropped out of our visive experience of the world' (Stafford 1993, p. 36). I suggest that this occurred not only because of the intangible size of the specimens but also as a result of the optical separation of form from matter. This phenomenon transpired because the optics of the compound microscope transformed the object under observation into a state of a virtual specimen, as in the process of increasing magnification. With his knowledge of optics, Hooke knew that when something is being viewed through sets of multiple lenses, what is actually being observed is a virtual image, which exists between the lenses. The process of compounding lenses essentially makes an image into an object; that is to say, the look of the specimen (comprising volumes without mass) supplants its referent and becomes the thing under observation. This is where the division of space and the certainty of location, as well as our notion of the real, start to become problematized in relation to scientific methodology. Here, I introduce my artwork, *Lucida*, which explores the ambiguous nature of image objects and also provides an entry to a discussion of *things*, seen and unseen

Lucida

In its design, I think of *Lucida* as a reconfiguration of a microscope that places the viewers within the instrumentation, creating a camera obscura (room) microscope hybrid of sorts.[19] Both of these technologies – the microscope and camera obscura – comprise light, lens, space, image, and observer, but in differing arrangements, with each instrument determining a distinct real-time viewing event: I think of this 'hybrid' vision working also to amplify their similarities and differences. Here, I am travelling not too far from the ways in which I imagine Hooke interrogating his earlier adventures in microscopy through his later invention of the wearable camera obscura. That is to say, Hooke creates a reiteration of a visual question to be engaged from an alternative perspective. However, compared to the fully immersive world of Hooke's instrument, which he designed for the individual to experience,

Lucida presents a relatively expansive environment that allows for a collective witnessing. In *Lucida*, generating sight is a whole-body experience, as gallery visitors are free to move around the darkened space to inspect the magnified images of microscopic structures, which seemingly protrude from the gallery walls, as well as the pared down instrumentation from which they emanate. Yet here within lies the confusion. In *Lucida*, there are no material *things* being imaged as such (or at least not in terms that we think of in regard to *reflection* or *likeness*). Indeed, determining exactly what is being imaged, and locating where the various images, and their 'host' specimens, reside becomes somewhat difficult to define. Essentially the artwork functions as an autonomous image-making machine, creating analogue images in real time, without generating a permanent record.

In practice, the images emerge from the 'intra-action' of light (a plasma arc coupled to fibre optic cables), glass (two 9 cm^2 clear plates purposefully made for the installation), and movement (incremental steps provided by stepper-motors) located within the enclosed walls of the darkened gallery (which contain also the gallery visitors who form part of this operational optical space). The small intensely bright light sources are directed at micro-fractures residing within the clear (rotating) glass plates, thereby enabling their previously invisible internal structures to be exteriorized as real-time images – measuring approximately 2 m^2 (Figure 8.1). Rarely synchronizing, as the separate glass plates move at different speeds and in opposing directions, they create a choreography that is controlled but not prescriptive. I had a dual intent in making *Lucida:* to extend the public experience of viewing microscopic anatomies (i.e., microscopic structures) beyond that of looking at documentation of some past imaging event and to provide a space in which to actively think through, and engage with, ideas visually. (Yet, in indicating this dual aim, I am not suggesting that the outcome was set in advance: artworks tend to exceed the resolve of the artist.) My broader concern at the time of making *Lucida* was to explore our contemporary fascination with transparency and the virtual, and our acceptance of both, as viable methods of observation, which I conceptualized as originating from the nineteenth-century microscopy and the century's emergent science of cytology – i.e., the study of cells. The increased magnification made possible by nineteenth-century advancements in optical technology 'seemed to make life itself

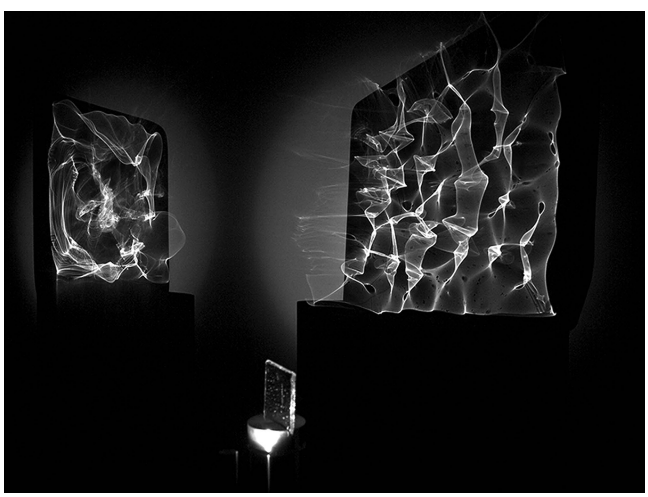

Figure 8.1 *Lucida* (installation at Fehily Contemporary, Melbourne, Australia) by Nina Sellars. (2012) © Nina Sellars

transparent, to enable the viewer to look into and through the object, not at it' (Armstrong 2008, p. 329). Essentially, I wanted to make strange our naturalized perception of this way of seeing in the twenty-first century and be immersed in 're-eventing' its emergence.

Things

From a contemporary standpoint, it can be said that to study a particular thing as isolated and objectified is to adopt a traditional scientific approach to a subject (here we see a Cartesian world of 'things' awaiting discovery, accompanied by an understanding of 'objectivity' that is 'assumed to be abstract, timeless, and monolithic' (Daston & Galison 2007, p. 51).[20] Through a process of systematic observation, documentation, and archiving, the data collected about a thing can be assembled into a body of knowledge. Embedded in this method is the expectation that there is an inner world of an observer, which is separate from an outer world to be observed; that is to say, the role of the observer is to be a detached subject who acts as the rational witness. This methodology is reliant on a demarcation of disparate spaces, aimed at defining a 'there to my here.' As Barad reminds us, '[r]epresentationalism takes the notion of separation as foundational' (Barad, p. 137). In microscopy, a slippage nevertheless occurs, as notions of interior, exterior, depth, and orientation become harder to determine and maintain. This phenomenon can be considered to be not only inherent to the observed object and to the technology of the microscope but also to the viewer's perceptual immersion in a magnified vision. As the world, which we experience in both spatial and temporal terms, is radically disrupted in the microscopic view, visual leaps are made from one scale to another that effectively suspend our sense of continuity and destabilize our concept of location. In contrast, linear perspective illustrations visually stabilize the viewer and provide a sense of spatiotemporal coherence. (Perspective being the exemplary Cartesian imaging space in which one can present 'discovered' things.)

Indeed, the key element of perspective, which proved so vital to early scientific illustration, was not the optical technology's ability to show objects three dimensionally, but rather its capacity to depict objects as existing together in continuous relative space. The study of anatomy provides a key example: perspective enabled the internal spaces of the body, and the organs they contain, to be 'realistically' depicted in their respective spatial relations. In other words, a perspectival representation does not show simply a cluster of objects; instead, it displays a coherent space, from a fixed viewpoint, with objects existing in it.

The art critic John Berger in his oft-cited book, *Ways of Seeing*, provides a description of the seemingly 'ocularcentric' nature of perspective:

> The convention of perspective, which is unique to European art and which was first established in the early Renaissance, centres everything on the eye of the beholder. It is like a beam from a lighthouse – only instead of light travelling outwards, appearances travel in. The conventions called those appearances reality. Perspective makes the single eye the centre of the visible world. Everything converges on the eye as to the vanishing point of infinity.
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> *Berger (1972, p. 16)*

Yet, relating this idea to my previous mention of texture makes clear that perspective also connects to the sense of touch – perspective is a *haptic* vision. As I have already implied, alongside its 'ocularcentric' nature, it could be argued that perspective as a convention relies on our real-world experience of touch, which is gained through our interaction with, and movement

through, the actual concrete places we encounter in our daily life. For example, you can never see more than three sides of an opaque cube, this is true both in perspectival images and in reality, but we know that a cube has six sides from tactile experience. As we turn an opaque cube in space, we observe a resolving sequence of views that coalesce into a dimensional object. The same can be said of our understanding of cubes on a larger scale, as we walk in and around architectural spaces. Therefore, by incorporating tactile memory, shapes in perspectival images can be perceived as tangible objects. Indeed, this act of visualization effectively animates the image, as we intuit the movements required to physically negotiate the virtual realm as though it were a real-world scene. Returning once again to the example of anatomy, the study of anatomy is founded on the ability to confirm visual knowledge with the touch of one's hand (with this understanding being the premise for perspective).

The low magnification of Hooke's microscope means that the specimens displayed in *Micrographia* appear tethered to a perspectival world, but monstrously outsized, as they seemingly struggle to escape through the picture plane. Some insects are depicted with their legs severed by the harsh cut of the perspectival framing, i.e., the great belly'd gnat (Schem. XXIX). Others such as the louse (Schem. XXXV) seem trapped just beneath the picture plane, whereas a fly's head (Schem. XXIV) ruptures the surface of the image as if breaking through the illustration (Figure 8.2). If we remain focused for a moment on the image of the

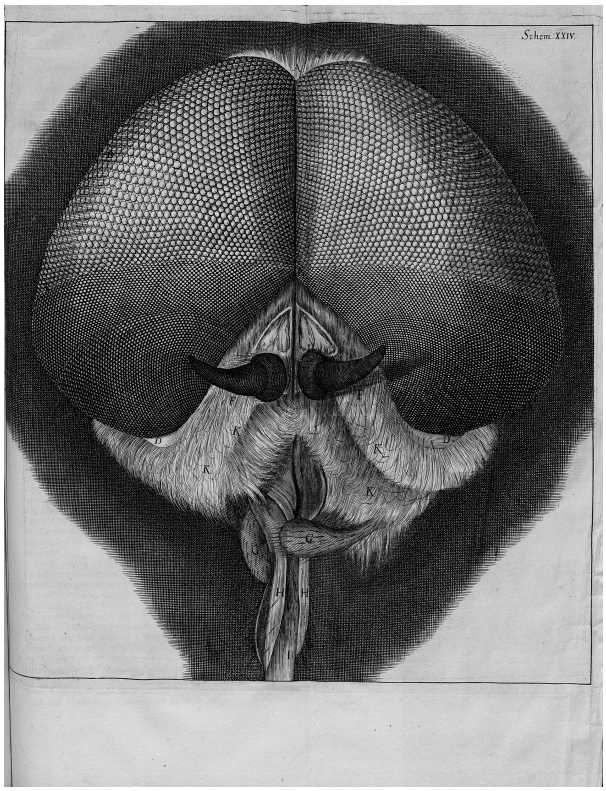

Figure 8.2 Schem: XXIV head of a grey drone-fly. *Micrographia: Or some physiological descriptions of minute bodies made by magnifying glasses: With observations and inquiries thereupon* by Robert Hooke (166 Rare Books Collection. University of Melbourne L

fly, in particular the antenna portrayed on the right, we can explore further the characteristic qualities of light as seen represented in the pictorial space of perspective. For example, the directional fall of the antenna's *cast shadow* makes clear the positioning of the fly's head in relation to the microscope's source of illumination (which enters the scene from a point, slightly raised, on the left). Moreover, at the base of the antenna, i.e., the part closest to the surface of the eye, the *cast shadow* appears sharp, yet as the antenna curves away from the surface of the eye, its shadow seems to soften as the light diffracts at the edges. What we are observing are the physical qualities of light, captured in the pictorial space of perspective. This example also highlights an important often-overlooked fact.

Renaissance perspectival representations were the first images to show light acting as a physical, rather than spiritual, entity (Shlain 1991). Whether as an artefact of the process or appearing by design, light, depicted in perspectival images, became an entity that appeared not only to *flow on*, but also *reflect off* surfaces, thereby interconnecting objects in space through relative illumination. In reality, a directly lit (opaque) object reflects light (to varying degrees, depending on the colour and texture of its surface) and this reflected light, though diminished in intensity, can enter the *form shadows* of objects located nearby. An object's *form shadow* provides information about the characteristic physical qualities of the object; however, when *reflected light* (from another object) enters the *form shadow*, it conveys information about the second object as well. A general guide I use in relation to the study of an object's *form shadow* is that *all information exists in the half-light* (Sellars 2012, p. 63). By this, I mean that all the information about the object itself, that is to say, the shape of the form and the texture of its surface, is revealed at the edge of a *form shadow* (just after its *core shadow)*, where the form turns from the shadow into the light.[21] However, *reflected light* on an object is the conveyance of (visual) information from one surface onto another surface through the transmission of light. The luminous glow created by *reflected light* entering an object's *form shadow* reveals, to a certain extent, the colour and surface quality of the second object as well as its proximity. Returning to the image of the fly, the cleft between the eyes provides a point at which to study the play of *reflected light*; here, light reflects between the two convex surfaces of the eyes – light hits the eye on the right directly, then reflects into the *form shadow* of the eye on the left. (Here, it should be noted that we are conceptualizing light as travelling in straight lines, which is expressed schematically using ray diagrams: this notion of light is not suitable for explaining the optical effect of diffraction.)[22] Foremost for illustrators, if the path of light is ever perceived as broken or illogical in a perspectival image, the illusion of plasticity and dimension collapses. Put simply, light is the architect of perspective. (This analysis could lead us to explore the mediation of light in the 'mark making' of illustrations; however, this would be a chapter in itself.)

The most striking component of *Micrographia* is the large foldout folio illustrations: challenging the capacity of the archive to contain this new vision, they far exceed the size of the book. It is important to remember that these are Hooke's illustrations, which he made while he observed the (often living, yet immobilized) insects through the eyepiece of the microscope (Inwood 2002, p. 67).[23] Like the specimens, he too was caught between two very different ways of seeing. In the text, Hooke also juxtaposes notions of the microscopic with terms that link to perspective, i.e., when he states that 'penetrating into the center and innermost recesses of the earth, and all earthly bodies; nay, it would open not onely a cranney, but a large window (as I may so speak) into the Shop of Nature' (Hooke, p. 177). However, here the window of perspective, albeit large, does not provide a view out onto the world, but rather has the viewer positioned outside, looking in. In another section, Hooke expresses his desire to 'Microscope in these smaller creatures, quietly peep in at the windows, without frighting her out of her usual byas' (Hooke, p. 146). Nevertheless, I suggest that for Hooke it

would have also seemed that these 'earthly bodies' were meeting him half way, with his realization that these virtual-object images were in actuality residing inside the drawtube of his compound microscope. Remember too that Hooke designed elements of the optics and was aware of the physics. I suggest in the making of *Micrographia*, Hooke was attempting to create a space, both ontological and epistemological, in which to locate this new visual knowledge.

In his writings on art and geometry, the art historian, William Ivins, provides an interesting theory in regard to vision and our intuitive understanding of space, which relates well to my examination of Hooke's practice. Ivins states that 'the eye has a point of view' and 'sees "there" where it is not' (Ivins 1946, p. 5). He argues the 'result is that visually things are not located in an independently existing space, but that space, rather, is a quality or relationship of things and has no existence without them' (Ivins p. 5). But what happens to the quality of space when 'there' is to be defined by a virtual object? And, further, what happens when an exact 'there' appears to exist simultaneously in two separate locations? We accept logically that this is the case with compound microscopy, but this acceptance is accompanied by the realization that the two 'theres,' so to speak, look nothing alike. In the example of Hooke, we have to say 'almost' nothing alike, as the low (50×) magnification of his microscope only allowed him to view the familiar as enlarged and intricately detailed. Therefore, for Hooke, this virtual object, the parasitic image, is unable to become completely separated visually from its host specimen, as it is still recognizable and appears somewhat related. This process must have frustrated Hooke's logic of space as well as his understanding of sight. This returns us to the question of Hooke's choice of instrumentation.

Seeing Things

In the following excerpt from *Micrographia*, Hooke describes the technological extension of the eye, stating that:

> The next care to be taken, in respect of the Senses, is a supplying of their infirmities with Instruments, and, as it were, the adding of artificial Organs to the natural; this in one of them has been of late years accomplisht with prodigious benefit to all sorts of useful knowledge, by the invention of Optical Glasses. By the means of Telescopes, there is nothing so far distant but may be represented to our view; and by the help of Microscopes, there is nothing so small, as to escape our inquiry; hence there is a new visible World discovered to the understanding (Hooke 1665, p. 5).[24]

The preceding statement from *Micrographia* implies that his aim was to extend vision to its furthest possible limits. Yet, if this was indeed the case, then why did he not use a single lens microscope that would have offered him a much higher magnification, in fact almost five times more than the compound microscope? The instrument was available to him, and he had used it before, and beneficially it would have optically flattened the space more than the compound microscope, somewhat alleviating the tension of being *between* these two ways of seeing. (Without space, perspective does not exist.) In addition, as the instrument had only one lens, no virtual images could be generated through the compounding of lenses, thereby negating any confusion about what is real (although again, Hacking would question this assertion). What then were the disadvantages for Hooke in using the single lens microscope? I suggest that a partial answer can be found in examining the design of the single lens microscope and then considering the phenomenological engagement that was incited by the two separate instruments.

The single lens microscope comprises a little droplet of polished glass, with a diameter of less than three millimetres, which is contained in a hand-held mount to be positioned close to the eye. The instrument appears more akin to a miniature magnifying glass than to our current idea of a microscope. However, it could achieve a magnification of 240×. In the Preface to *Micrographia*, Hooke instructs on how to make a simple lens; however, he also describes the instrument as 'very troublesome to be us'd, because of their smallness, and the nearness of the Object' (Hooke 1665, p. 5). In a lecture in 1678, Hooke again indicated his aversion to the simple lens microscope stating:

> I have found the use of them offensive to my eye, and to have much strained the sight, which was the reason why I omitted to make use of them, though in truth they make the object appear much more clear and distinct, and magnifie as much as the double Microscopes: nay to those whose eyes can well endure it, 'tis possible with a single Microscope to make discoveries much better than with a double one…
>
> *Hooke (1678, p. 16).*

I suggest that Hooke's discomfort with the single lens microscope was because it gave no externalized space for him to conceptualize the image. That is to say, the image neither resembled the original specimen nor existed as a virtual image; therefore, in Ivins terms, there seemingly was no 'there' to define this act of seeing. Perhaps, the single lens microscope provided Hooke no buffer to the effects of magnification as the image effectively affronted his eye – locating a 'there' likely to be injurious to the eye – whereas the compound microscope could provide a place for the virtual image object to be contained. In the latter, the image, as object, exists in the drawtube casing in-between the lenses, somewhat assisting in defining a 'there' to the observer's 'here,' but with all the complications that a virtual 'there' provides. Nevertheless, I propose that this provision of space was an important element for Hooke, providing him with the ability to conceptualize things as residing in a coherent space, as being somewhere, but also as being somehow contained. I imagine it to be all the more important when the image no longer resembles the original specimen, as would be the case with the single lens microscope, which rendered the familiar, strange.

In considering Hooke's use of the single lens microscope, in comparison with the compound microscope, I return to examine the choreography of observer and instrument in the act of observation. Here, I adopt an approach influenced by media theorist, Marshall McLuhan: particularly his idea that the formation of a new technology provides relief from an over-stimulated sense or function by disconnecting it from the body (McLuhan 1964). According to McLuhan, the process numbs us to the realization that the new technology is an extension of ourselves; therefore, it appears to us as an *other* which fascinates, automatically creating a *closed system* between body and technology (McLuhan 1964). I consider Hooke's use of a single lens microscope as an instance of an overstimulated sense. However, rather than providing relief through technological extension, by 'the adding of artificial Organs to the natural,' I conceptualize it is a sustained irritation (Hooke 1665). By this, I mean the use of the single lens microscope can be visualized as a tugging, pulling, and extending of the cornea, which artificially amplifies its ability to focus, though never severing its anatomical connection to the eye. In contrast, it can be imagined that the compound microscope effectively disconnected, and provided relief for, Hooke's over-extended eye by providing a space for the optical image to reside away from the eye's surface. For Hooke, this freestanding instrument constitutes the *other*, a technology that fascinates him.

Pursuing this idea further, we can turn to McLuhan's argument that an opportunity to stand outside the *closed system* is presented at the moment when two mediums combine and develop into a new form through a process of *hybridization* (McLuhan 1964). He states that the alternating perspectives provided by the initial contrast have the effect of heightening our awareness, as the traits of one medium expose the qualities of the other. As previously mentioned, I see such an opportunity arising with the initial contrast that took place in early microscopy, when the microscopic view met with perspective. Moreover, Hooke seemingly exemplifies the frustrations and fascinations that McLuhan highlights in relation to technology. Indeed, I consider Hooke's invention of a wearable camera obscura to be a form of McLuhanian *closed system*. However, I also explore the device in terms of Hooke's phenomenological experience, as being both embodied and embedded in a (mediated) world, and as an iteration of his 'actively thinking' method of 'true philosophy.'[25] I imagine Hooke in the Heideggerian understanding of *being-in-the-world* in that he is literally thrown into a process of making sense of the world that begins with being perplexed by his own existence (Heidegger 1927). In this way, the wearable camera obscura becomes a way of making sense of the immersive visual experience of microscopy.

The only image of Hooke's invention is a woodcut print that accompanies the written submission he made to the Royal Society (Hooke 1694). The picture is of a man walking through a landscape while wearing the camera obscura, but the instrument itself is illustrated as a cutaway that allows the user to be fully seen, so in effect his upper body appears as the internal workings of an image-making machine (Figure 8.3). Seemingly, Hooke's fascination with microscopy has now driven the body into the optical instrument. It is not that the

Figure 8.3 *An Instrument of Use to take the Draught, or Picture of any Thing…*by Robert Hooke. (1694) © The Royal Society

wearable camera obscura magnifies his view, but it does replicate the enveloping, mediated vision provided by microscopy. I suggest that Hooke's conversion of the camera obscura into a wearable technology enabled him to be immersed in a technologically mediated vision. It was as if Hooke had made a model that allowed him to imagine his body positioned inside the drawtube of a compound microscope, where he could move through the virtual image. In practice, the lower half of the body appeared to be providing locomotion for a somewhat distended cyclopic head – which had absorbed the other four main senses. As with microscopy, Hooke's sense of touch is limited to experiencing the world through mediated sight, disconnected from the immediacy of material things, as he can no longer touch what he can see. The whole process can be understood as Hooke taking the *task envelope* of microscopy and reconfiguring its relationship to the body and to space. It is also an attempt to find another way of exploring the perceptual and conceptual tensions raised by microscopy. Therefore, Hooke's camera obscura can be thought of not only as an amplified visual experience and a new way of experiencing images but as also offering another possible way of experiencing the body as a whole – similar to that engendered by microscopy.

Hooke is once again immersed in a vision where notions of interior, exterior, depth and orientation are hard to define, and the demarcation of disparate spaces, aimed at defining a 'there to the observer's here,' is equally slippery to explain. The world for Hooke appears collapsed onto the glass ground plate, which acts as a screen, bringing everything close to hand as both hand and eye are set the same task of seeing. The world effectively becomes an image to Hooke. A visual experience opens up that is more akin to a twenty-first century heads-up display than to a seventeenth-century camera obscura. It challenges the expectation that there is an inner world of an observer that exists separately from an outer world to be observed. Vision is no longer of something, but is rather defined as an (all-encompassing) experience. To add to the confusion, there is also the task of having to determine where vision, in this extended technological eye, is actually located. Does it reside on the glass plate, in the fingertips, or is it circling indefinably within the interior space of the instrument?

Making Hooke's vision even more complex is that the image most likely appeared to Hooke as inverted and reversed on the camera obscura glass ground plate. Interestingly, and taking a slight tangential step into experimental psychology, this disorientating view would have had a durational limit because, depending on how committed Hooke was to his experiment, his brain would eventually adapt to the 'artificial organ' by self-correcting the vision. However, once the device was removed, the brain would go through the process again in reverse (Kohler 1962, pp. 62–86). Of course, this was unlikely to be Hooke's intention, though he did seem to expect some dedicated wearing of the instrument. In one passage, Hooke describes a mariner standing on the deck of his boat wearing the instrument, glancing 'time to time' at the coastline, while remaining stationary in his relative position as the ship traverses the sea (Hooke 1694, p. 295). He states that in wearing his device, 'the Mariner may easily and truly draw the Prospect and from Time to time denote the Rising thereof, as he does nearer and nearer approach it, and the Depression, or Sinking of it, as he does recede' (Hooke, p. 296). Not only does this vision seemingly have no fixed horizon to allow for an image to be made, negating any practical claim as a recording instrument, Hooke also appears to equate vision to the drawtube focus of the compound microscope, with the mariner's vision drawing in and out with the tide.

Hooke's wearable camera obscura is not fiction, it did exist, but my question is whether it was really designed for travellers wanting to document their sightseeing. Or did Hooke provide this description only as a playful justification for his experimentation with altered perception? Perhaps, Hooke himself was perplexed by what may have been an inexplicable

desire to construct this device. In part, this is why I find Hooke of interest, as he is positioned on a threshold, effectively opening up a space of visual and conceptual uncertainty, which can be questioned and explored. Keeping this in mind, my objective in conclusion is to suggest similarities between Hooke's phenomenological experience of imaging and our own contemporary engagement with images. In addition, I return to the ethical imperative *to cut better* in the discipline of anatomy.

Seeing things differently

I am not saying that what is being experienced today in our twenty-first-century engagement with images (both in the realm of science and more broadly, i.e., in our current visual and media culture) is an re-enactment of the original hybridization of microscopy and perspective, important differences appear – differences that I relate to Hooke's experimentation with the camera obscura (which I consider as an example of Hooke's 'true philosophy'). Importantly, and somewhat similarly to Hooke, the methods that we now use to create and view images are appearing to complicate prior notions of reality, for example, augmented reality, mixed reality, and virtual reality. As it could be said that, to a large extent, we no longer look at images, but rather, we interact with images in multiple dimensions and in multisensory ways. Indeed, it would appear that any contemporary definition of the word image will need to question where the image appears, how it appears, and how it relates to (our general understanding of) reality, i.e., is the viewer assimilated into the view of the image, or more interestingly, is the image behaving as an object. Moreover, my conceptual framework – *the task envelope of light* – proves less effective in resolving questions about image-making in our 'post optics' era, as increasingly images arise from algorithmic data, not the indexical capture of light reflecting off surfaces. Yet, a broken framework still provides ways in which to think through ideas (i.e., the break in itself provides insight). I close this chapter with my latest biological artwork, *Sentinels*, which, in part, arose from one such example: when I began to think about light sources that penetrate (the body) rather than illuminate (its surfaces). I am referring to the diagnostic imaging technologies that employ frequencies from the extremes of the electromagnetic spectrum, specifically X-ray, computerized tomography (CT), and magnetic resonance imaging (MRI). (Yes, I have a very generous understanding of what counts as light.)[26] MRI is of particular interest as it also resides in the category of 'post optics,' i.e., MRI images do *not* originate from optical information, but instead are generated from data sets of Cartesian coordinates. These data sets represent parallel, sequential layers of the body, which can be digitally restacked and realigned to form virtual volumetric images. The neuroscientist, Richard Wingate, states, 'a computerised reconstruction produces a facsimile of material substance that can be rotated, re-rendered, paused or magnified' (Kwint & Wingate 2012, p. 27): his description (of a brain model) exemplifying the vision that I envisaged as originating with Hooke.

One of the most interesting qualities of MRI is its acute sensitivity to recording adipose tissue (unlike X-ray and CT); however, it is often treated as an artefact and removed algorithmically in the digital pre-processing of the image. Historically, fat rarely appears in the visual archives of anatomy or at least rarely in a way that appears meaningful, and MRI algorithms seemingly repeat the cut, thus creating a strange continuity of vision that aligns the computer-generated volumetric imagery composed of MRI data sets with the normative representations of the anatomical body presented in the perspectival illustrations of anatomy atlases. Seemingly, fat exists in an anatomical body, but is not *of* anatomical knowledge. This absence raises the dual question: what is our investment in unseeing fat in the study of

anatomy and the implications of its exclusion within the life sciences? Keep in mind also that anatomy is the field of study that not only underpins Western medical knowledge but also increasingly informs the contemporary understanding of the body more generally (Kuriyama 1999, p. 117).

Sentinels

In making the biological art installation, *Sentinels*, my aim is to question the cultural and scientific implications of the relative absence of fat in the history of anatomy and the significance for contemporary discourses about the human, the non-human, and the post-human. In the context of its inaugural showing, as part of the exhibition, *HyperPrometheus: The Legacy of Frankenstein*, Perth Institute of Contemporary Art, Australia, the work was meant as a provocation for us to think beyond anatomy as our normative frame of reference. The installation displays human pre-adipocyte tissue culture (aka fat – living, and growing, in vitro) embedded in a replica of an archaic Greek kouros statue, cast in (GelMA) hydrogel. The sixth-century BCE kouroi predate the arrival of anatomy; however, they were the first statues in archaic Greece to show movement: one leg placed further forward, as if tentatively entering into this new understanding of the body. The installation centres on a custom-made incubator: appearing either side are nine-foot high real-time video projections showing selected elements inside the incubator (Figure 8.4). On the left, the gel kouros being drip fed nutrients in its wet environ; on the right, the original vial in which the human pre-adipocytes were transported on dry ice from the United States (the now empty vial positioned in the incubator alongside the living korous). The visible section of the vial label reads: 'Primary Subcutaneous Normal, Human, Lot # 63569630, store at <−130°C.' When contrasted with the kouros, the sentinel-like figure of the cell vial is suggestive of a period post-anatomy.

The biological installation, *Sentinels*, is part of an ongoing series of artworks that I intend as thoughtful (fat) interventions in the historical archives of anatomy, i.e., its museum collections and compendia. These are small gestures, not grand statements, and in no way are to appear 'useful.' Similar to my take on Hooke's true philosophy, they signify an attitude of 'actively thinking' rather than an act of 'utilitarian doing.' In regard to the performance of anatomical knowledge, I want to suggest that we have the possibility of seeing, and doing, otherwise.

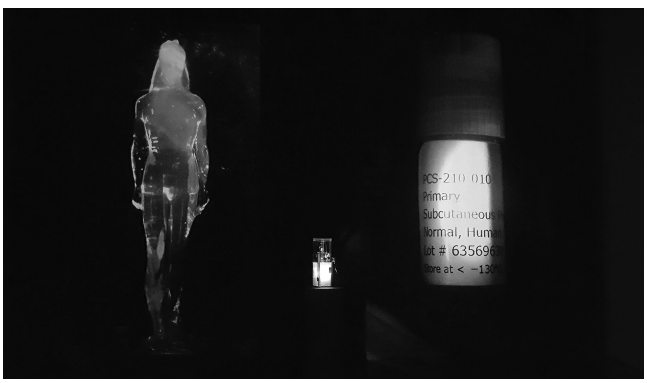

Figure 8.4 *Sentinels* (installation at Perth Institute of Contemporary Arts, Western Australia) by Nina Sellars (2018) [illegible]a Sellars

Notes

1 A standard portable camera obscura, though it may be movable, is not wearable and requires both instrument and observer to remain still: stillness being the basic prerequisite for capturing an image, i.e., to draw a 'realistic' representation by means of tracing the outline of the projected 'real'-world scene as it appears on the ground glass plate of the camera obscura apparatus. Notably, Hooke presents the simultaneous movement of instrument and observer as a design feature of his wearable camera obscura, thus compromising its utilitarian value as a recording device.

2 Hooke describes two iterations of his camera obscura. The earlier design is recorded in his Royal Society lecture notes of 1681. See Robert Hooke, 'A Continuation of the Former Subject of Light. Being the Lectures Read in June, 1681,' *The Posthumous Works of Robert Hooke*. Edited and Published by Richard Waller (London: Printed by S. Smith and B. Walford, 1705), 127–128, plate 1, Figure 7. Here, Hooke provides instruction on how to construct an experimental apparatus for explicating functions of the eye (these notes appear after his description of his undertaking of a detailed dissection of an eye). The latter design, a drawing instrument (i.e., the wearable camera obscura discussed in this chapter), was presented in a lecture to the Royal Society in 1694. See Robert Hooke, 'An Instrument of Use to Take the Draught, or Picture of Any Thing. Communicated by Dr Hook [sic] to the Royal Society Dec. 19, 1694,' William Derham, *Philosophical Experiments and Observations of the Late Eminent Dr. Hooke* (London: Innys, 1726), 292–296. The ways in which the two designs vary are important – in the earlier design, Hooke indicates that only the face of the observer peers into the apparatus, whereas in the later design, i.e., the wearable camera obscura, the entire upper body of the ambulant observer, i.e., their face, head, arms, and torso, appear enclosed within the instrument. Keep in mind that this would also capture what are traditionally considered as the five key senses of the body: sight, hearing, touch, taste, and smell. Moreover, it could be suggested that the enclosed capsule created an environment in which oxygen and carbon dioxide exchange would become restricted, altering the pH levels within the body of the instrument wearer, leading to dizziness and confusion.

3 R. Hooke, *Micrographia: Or Some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses with Observations and Inquiries Thereupon*. 1st ed. (London: Martyn and Ja. Allestry, Printers to the Royal Society London, 1665). Available from: https://www.bl.uk/collection-items/micrographia-by-robert-hooke-1665/ [Accessed 20 July 2019].

4 For an example of its reception, two diary entries from the seventeenth-century politician and diarist, Samuel Pepys, express his first-hand engagement with *Micrographia*. On 20 January and 21 January 1665, Pepys writes that having purchased a copy, he 'there took home Hooke's book of microscopy, a most excellent piece, and of which I am very proud.' *Micrographia* then crosses the threshold of Pepys' home and continues to enchant him. The following day, Pepys' diary entry reads: 'Before I went to bed I sat up till two o'clock in my chamber reading of Mr. Hooke's *Microscopical Observations,* the most ingenious book that ever I read in my life' (Pepys 1665).

5 The artwork, *Lucida*, was initiated while I was Artist in Residence at the Pilchuck Glass School, Seattle, USA, 2008, and was further developed with the assistance of the Solid-state Spectroscopy Group, Laser Physics Centre, Research School of Physics and Engineering, Australian National University, 2010 and 2012. Craig MacLeod (technician/mechanical engineer) assisted with the fabrication of the instruments, and Associate Professor, Matthew J. Sellars (quantum physicist), was the advising scientist. A prototype of *Lucida*, titled *Lumen*, was exhibited at GV ART, London, as part of the group exhibition, *Art and Science: Merging Art and Science to Make a Revolutionary New Art Form*, 2011, curated by Robert Devcic and Professor Arthur I. Miller. *Lucida* was exhibited at Fehily Contemporary, Melbourne, as part of my solo exhibition, *The Optics of Anatomy and Light*, 2012.

The artwork, *Sentinels*, was created while I was 'Artist in Residence' at the SymbioticA biological arts laboratory, The University of Western Australia, and the Solid-state Spectroscopy Group, Laser Physics Centre, Australian National University, 2018. *Sentinels* was made for the exhibition, *HyperPrometheus: The Legacy of Frankenstein*, Perth Institute of Contemporary Art (PICA), curated by Laetitia Wilson, Oron Catts, and Eugenio Viola, as part of SymbioticA's *Unhallowed Arts* Festival, 2018. The *Sentinels* installation at PICA contained human pre-adipocytes (i.e., precursor fat cells) living and growing in a hydrogel (GelMA). The GelMA hydrogel was generously provided by Dr Christoph Meinert, Centre in Regenerative Medicine, Institute of Health and Biomedical Innovation, Queensland University of Technology. Assistance in the production of *Sentinels* at SymbioticA, UWA, was provided by Mike Bianco, Oron Catts, Callum Siegmund, Nathan

Thompson, and Dr Ionat Zurr. At the Solid-State Spectroscopy workshop, ANU, assistance was provided by Matthew Berrington, Craig MacLeod, and Assoc. Prof. Matthew J. Sellars. My initial fat tissue culture research and development – 'Fat Culture' – was undertaken while I was Artist in Residence at SymbioticA, 2016, funded by the Australia Council, with further in-kind support provided by SymbioticA, UWA, 2017 and 2018. The *Sentinels* installation was featured in the ABC short documentary, *Art Bites Biogenesis: Sentinels*, produced by Blue Forest Media, 2019 (First aired 10 August 2019. Available on demand via ABC iview, geo-locked to Australia.) Advice on adipose tissue provided by my 'fat' mentors, J. William Futrell and Ramón Llull.

6 Here, my understanding of the term 'performed' is derived from the notions of 'performativity' that appear in the studies of media theory and cultural studies (Austin; Barad; Butler; Derrida). 'Performativity is an empowering concept, politically and artistically, because it not only explains how norms take place but also shows that change and invention are always possible' (Kember & Zylinska 2012, p. 189). This idea expresses exactly the attitude I adopt in my approach to Hooke's work. Moreover, the term 'form' appears closer in meaning, i.e., being only a transitory stage in the world's ongoing 'performativity' of which we too are merely a fluid (resolving/dissolving) part.

7 I don't mean to simply illustrate the work of theorists, but rather to actually think through your work – toss ideas around visually, see things a little differently, and ask questions through your practice, but feel no obligation to proffer solutions. I return here also to the media theorist, Joanna Zylinska, and her text, *Life after New Media: Mediation as a Vital Process* (2012), co-written with Sarah Kember. In the text, Zylinska's thoughts on creative practice, in particular her engagement with photography, are outlined:

> [t]o be interesting, creative practice, including photography, for her has to mobilise complex thought processes, although without doubt it should do *more* than just illustrate already worked-out ideas and concepts. The very nature of this 'more' constitutes part of the invention process activated throughout this project.
>
> (Kember & Zylinska 2012, p. 198)

The project referred to here is Kember and Zylsinska's Creative Media project. Kember and Zylinska state that '[w]orking in and with media is for us first and foremost an epistemological question of how we can perform knowledge differently through a set of practices that also "produces things"' (Kember & Zylinska 2012, p. 188). Kember's creative practice is writing fiction and Zylinska's is photography.

8 'Art' can be many things, but the genre of 'art & science' remains intrinsically linked to institutions, and this relationship and its history need to remain open to interrogation.

9 I view light-based technologies as influencing the way in which anatomical knowledge is enacted and conveyed (with each light-directing technology creating, and delineating, a *task envelope of light*, distinct to each instrument). For example, the quality of illumination evidenced in perspectival illustrations of the Renaissance era supports the Vesalian method of teaching anatomy (Andreas Vesalius being the founder of modern anatomy and author of *De humani corporis fabrica* (1543), the first anatomical atlas to use perspectival images). Perspective is a light-based technology that offers a 'haptic' vision, an idea I will return to in this chapter to give further explanation. The notion of a haptic vision matched Vesalius's dictum that the study of anatomy should combine visual observation with 'hands-on' dissection, and Hooke used perspective to make the microscopic world appear palpable, i.e., within reach of the hand. For now, think of perspective as being an invitation to touch. (In regard to the notion of *the task envelope of light*, X-ray penetration of the body captured on photographic film in the twentieth century provides another example for comparison. Transparency became a diagnostic tool with the invention of the X-ray enabling the anatomy of a living body to be viewed.)

10 Here, we should be clear that Barad, similarly to Haraway, is not interested in defining differences as absolutes, but rather in mapping where the effects of differences appear (in their ongoing intra-actions). See note 12 for the definition of Barad's neologism, 'intra-action.'

11 Diffraction patterns are exhibited not only by light waves but also water waves and sound waves. (Moreover, we could add matter, electrons, and neutrons.) 'Diffraction has to do with the way waves combine when they overlap and the apparent bending and spreading out of waves when they encounter an obstruction' (Barad, p. 28).

12 The neologism 'intra-action' is a key component of Barad's theory of agential realism.

> The neologism "intra-action" *signifies the mutual constitution of entangled agencies*. That is, in contrast to the usual "interaction," which assumes that there are separate individual agencies that precede their interaction, the notion of intra-action recognizes that distinct agencies do not precede, but rather emerge through, their intra-action.
>
> (Barad, p. 33)

13 It is important to understand the terms 'agency' and 'reality' as used in the context of Barad's 'agential realism' framework: '[a]gency is an enactment' not an attribute of individual subjects or entities, and 'reality' consists of phenomena, i.e., the entangled effects that differences make (Barad, p. 178). In a broader sense, '[r]ealism, then, is not about representations of independent reality but about the real consequences, interventions, creative possibilities, and responsibilities of intra-acting within and as part of the world' (Barad, p. 37).

14 Historically, anatomy is a discipline informed by a series of 'cuts' – both physical and visual. At its etymological origins in ancient Greek, the word *anatomy* literally means *to cut* the body asunder. This makes anatomy directly related to the act of dissection (late Latin – anatomia, from Greek – ana-'up'+tomia 'cutting' from temnein 'to cut').

15 It has been noted that texts such as 'Gulliver's Travels could not have been written before the period of microscopic observation, nor by a man who had not felt at once the fascination and the repulsion of the Nature which that instrument displayed' (Nicholson 1935, p. 50).

16 Hooke was said to be a prodigious drawer and model maker as a child and for a time was apprenticed to the portrait painter, Sir Peter Lely. See Richard Waller, 'The Life of Robert Hooke,' *The Posthumous Works of Robert Hooke*. Edited and Published by Richard Waller (London: Printed by S. Smith and B. Walford, 1705), ii.

17 The 'a' in *différance* is a deliberate misspelling by Jacques Derrida of the French word, *différence*. The 'a' is a 'graphic intervention' in the word (i.e., it is seen when written, but not heard when spoken). Derrida uses this (f)act as a way to subvert what he sees as the traditional privileging of speech over writing (one example of the sets of binary hierarchies that characterize the Western tradition, in which one element is elevated as primary, while the other is seen as derivative or supplementary – in this instance, speech is considered primary). The term *différance* plays on the dual definition of the French word *différer*, which means both 'to defer' and 'to differ' – for Derrida, *différance* indicates both a deferral of meaning and meaning through difference. Neither a word nor concept, *différance* gestures at a diverse assemblage of qualities that govern the production of (con)textual meaning (Derrida 1982, pp. 3–27). The term implemented by Derrida as a way in which to suspend the force of the asymmetrical binary hierarchies of metaphysical thought that are exposed in the process of doing deconstruction (Derrida 1981, p. 43). See also, G. Hall, Cultural Studies and Deconstruction. In G. Hall and C. Birchall, eds., *New Cultural Studies: Adventures in Theory*, 1st ed. (Edinburgh: Edinburgh University Press, 2006), 31–52.

18 The understanding of 'form and matter' that underpins Western knowledge comes from Aristotle's theory of hylomorphism. *Hylomorphism*, from the Greek *hyle* (matter) and *morphe* (form). Anthropologist, Tim Ingold, provides an introduction to the theory of hylomorphism. T. Ingold, *Making: Anthropology, Archeology, Art and Architecture* (London and New York: Routledge, 2013), 20–31. The section also includes a discussion of key concepts that outline ways in which to overcome hylomorphism that have been proposed by philosophers, Gilbert Simondon, and Deleuze and Guattari. Returning to the above note (17), if considered in Derridean terms – i.e., as an example of the sets of binary hierarchies that characterize the Western tradition in which one element is elevated as primary, while the other is seen as derivative or supplementary – form is seen as the primary element and matter the inert passive receiver of form.

19 For an excellent evaluation of instrumentation, in particular, the camera obscura as well as notions of the 'observer,' see J. Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambridge, MA: MIT Press, 1990).

20 Daston and Galison have made explicit the importance of interrogating notions of 'objectivity' in relation to the given era, and that it has a history, i.e., objectivity is *not* to be thought of as being 'abstract, timeless, and monolithic' (Daston & Galison 2007). Barad provides a definition of objectivity in relation to the concept of *agential realism* (Barad 2012, 361). For Haraway, '[f]eminist objectivity means quite simply *situated knowledges*' (Haraway 1988, p. 581).

21 A *core shadow* is the darkest section of the *form shadow*, which appears just prior to the point where the *form shadow* turns into the light. Perhaps, the term *core shadow* is best understood in relation to a similar term used in astronomy, *terminator*, which indicates the dividing line between the illuminated side and the dark shadow side on a planetary body.

22 The two main divisions of basic optics are geometric (ray) optics and physical (wave) optics. Geometric optics provides an insight into the basics of light reflection and refraction and the use of simple optical elements such as mirrors, prisms, and lenses (and are explained visually using ray diagrams). Physical optics provides an insight into the phenomena of light wave interference and diffraction. For comparison, quantum optics deals specifically with photons (particles of light) in their interaction with matter. Photons behave like a particle and a wave, simultaneously.

23 However, the engraver of *Micrographia's* final plates, i.e., the person who translated Hooke's drawings into etchings, is unnamed in the text.

24 For a discussion of the impact of these technologies on the era's understanding of the eye and the separation of optics and sight in mediated vision, please see '*Baroque Science*' (Gal & Chen-Morris 2013, pp. 7–8).

25 In its 'continual passage,' a further iteration of Hooke's 'true philosophy' might find Hooke taking a stance similar to that of Haraway in her writings on situated knowledges. The construction (of the wearable camera obscura) perceived as an act of 'loving care' undertaken 'to learn how to see faithfully from another's point of view, even when the other is our own machine' (Haraway 1988, p. 583). Here, the *other* (the microscope) presents less as an extension or reflection of ourselves, which 'fascinates,' and more as a respectful meeting that elicits an expression of thoughtfulness towards the *other* (i.e., by way of the construction of the camera obscura), which, at the same time, decentres the human or at least their importance.

26 J. D. Wilson, A. J. Buffa and B. Lou, *College Physics*, 8th ed. (Upper Saddle River, NJ: Pearson Prentice Hall, 2009), 679.

> The electromagnetic spectrum is continuous. An electromagnetic wave (light) consists of time-varying electric and magnetic fields that propagate at a speed of c (3.00×108 m/s) in a vacuum. The different types of electromagnetic radiation (such as UV, radio waves, and visible light) differ in frequency and wavelength.

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